FIG. 1

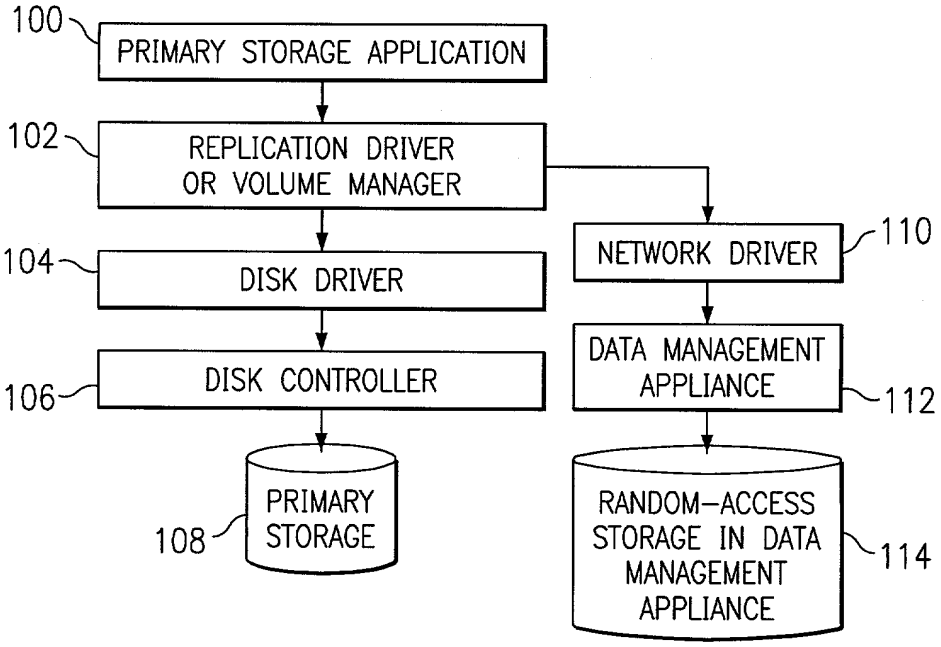


FIG. 2

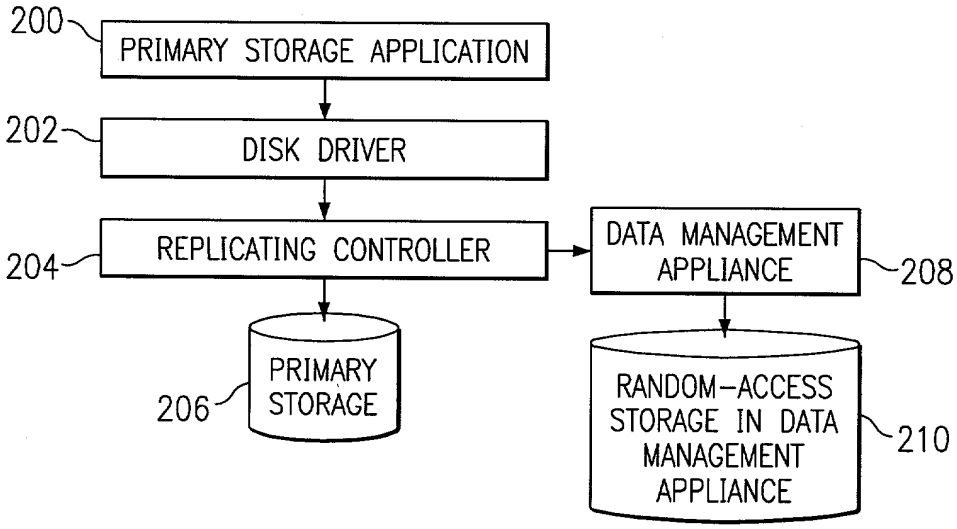
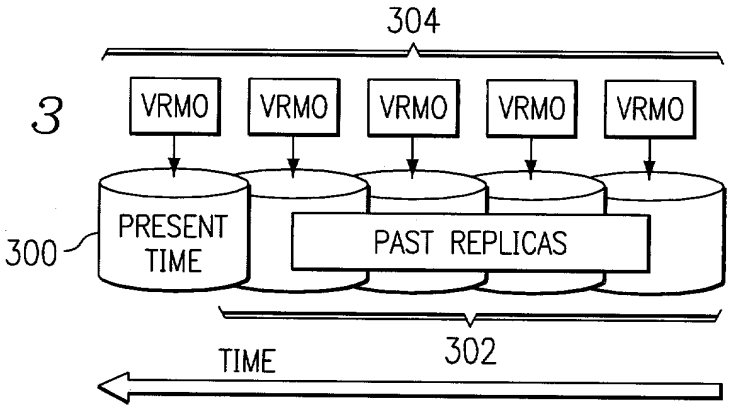


FIG. 3



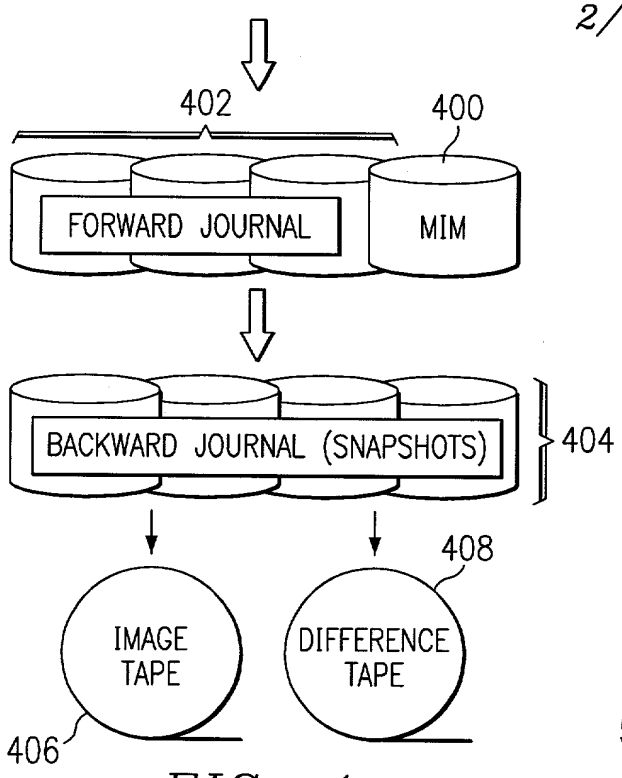


FIG. 4

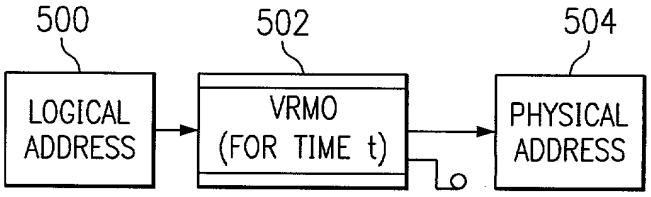


FIG. 5

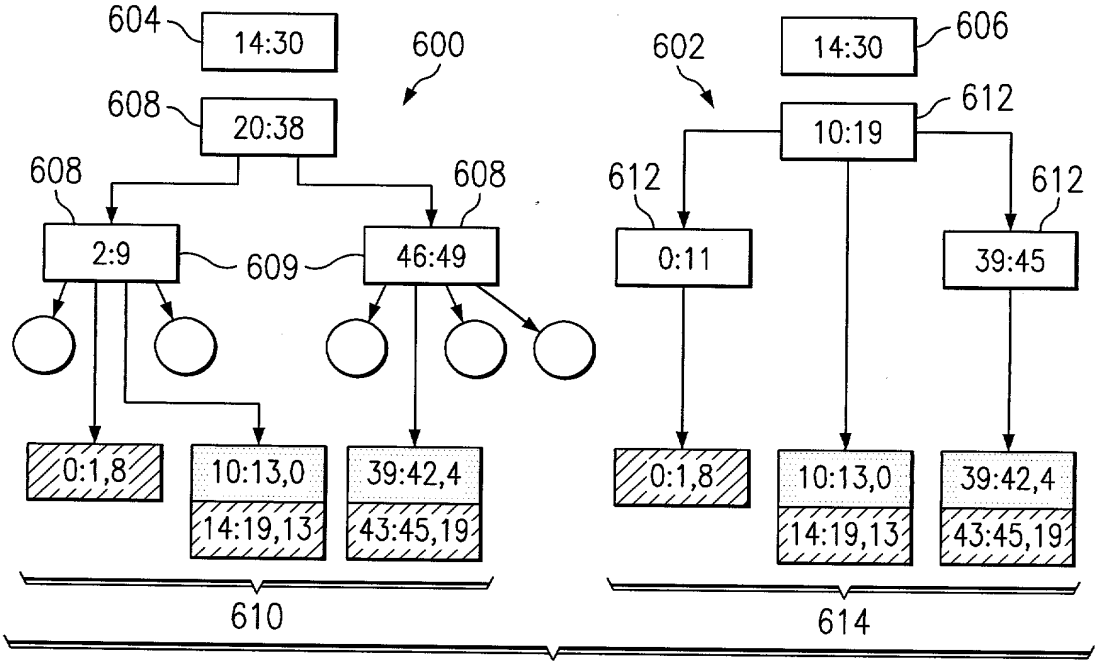


FIG. 6

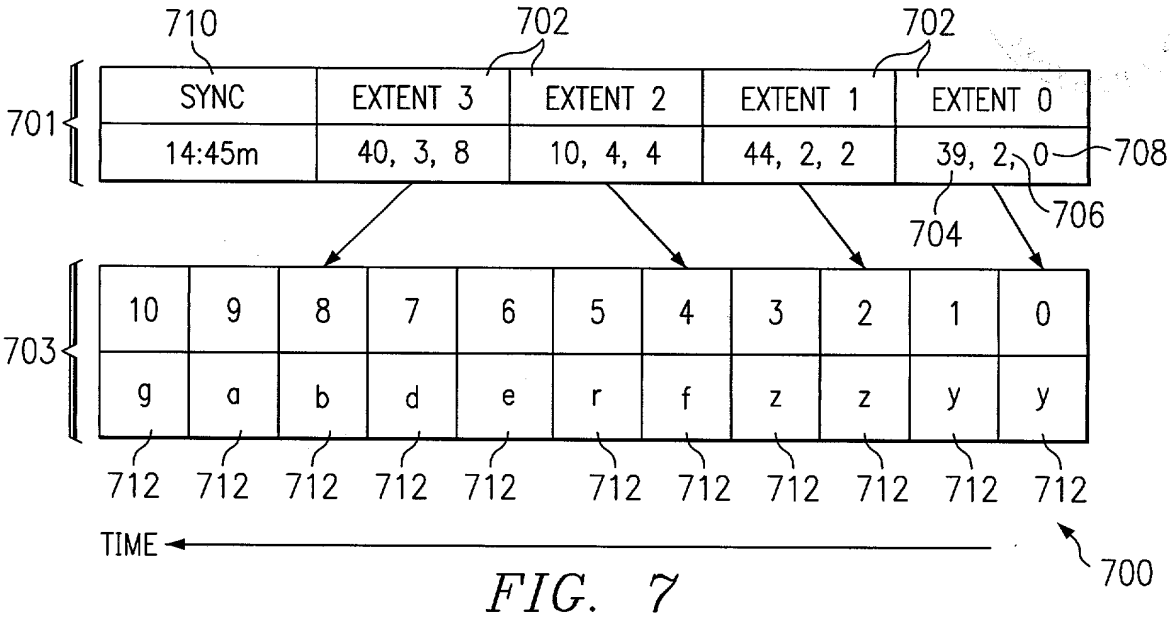

710
702
702
701
SYNC
EXTENT 3
EXTENT 2
EXTENT 1
EXTENT 0
14:45m
40, 3, 8
10, 4, 4
44, 2, 2
39, 2, 0
708
704
706
703
10 9 8 7 6 5 4 3 2 1 0
g a b d e r f z z y y
712 712 712 712 712 712 712 712 712 712 712
TIME
700

FIG. 7

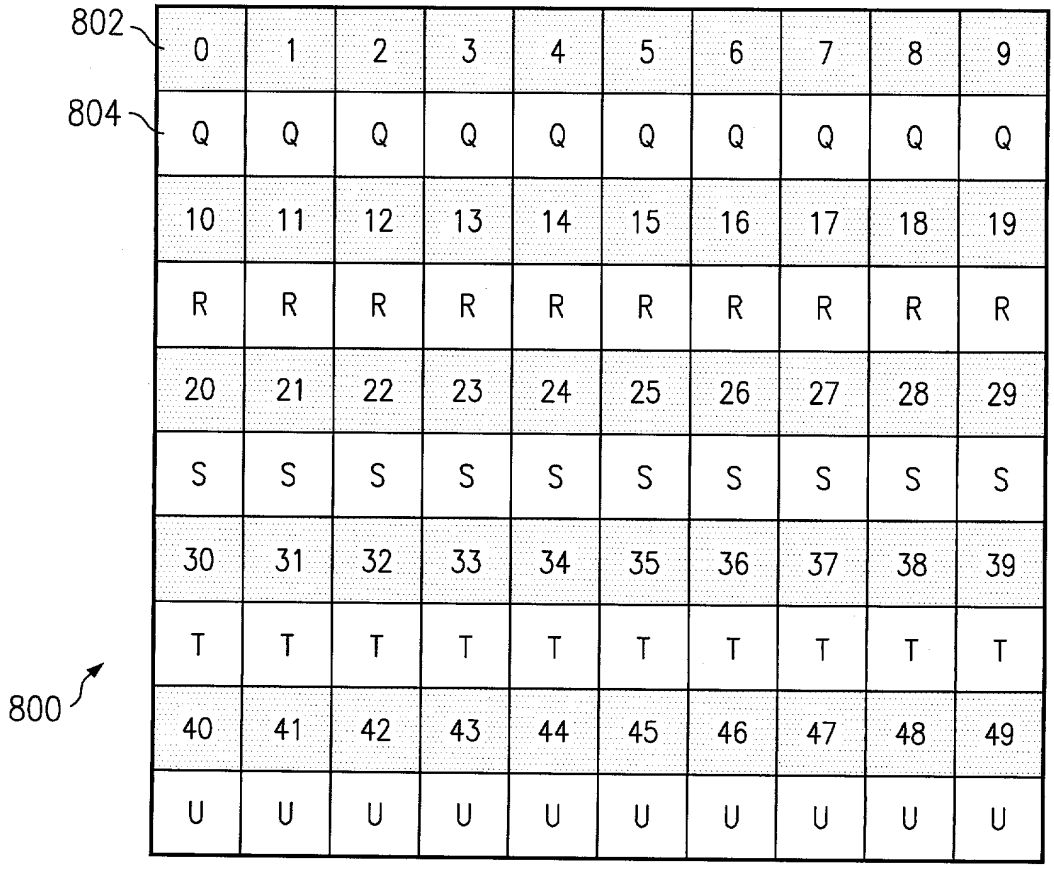

802
804
800
0 1 2 3 4 5 6 7 8 9
Q Q Q Q Q Q Q Q Q Q
10 11 12 13 14 15 16 17 18 19
R R R R R R R R R R
20 21 22 23 24 25 26 27 28 29
S S S S S S S S S S
30 31 32 33 34 35 36 37 38 39
T T T T T T T T T T
40 41 42 43 44 45 46 47 48 49
U U U U U U U U U U

FIG. 8

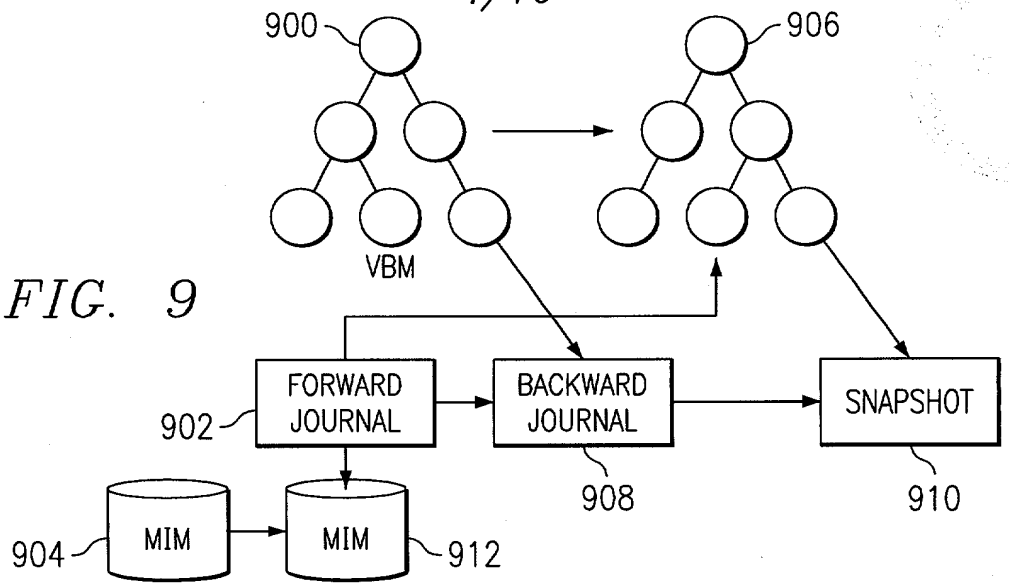


FIG. 9

FIG. 10

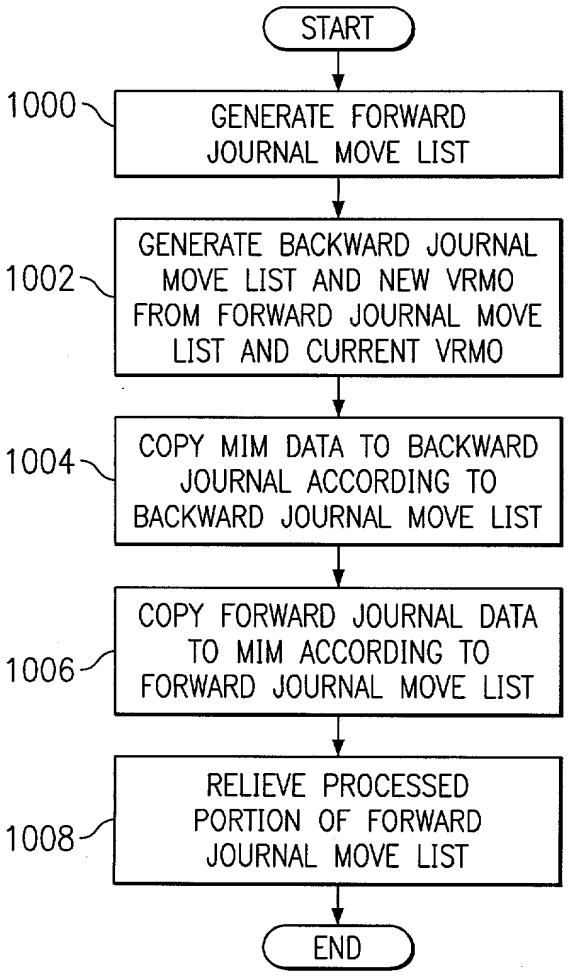
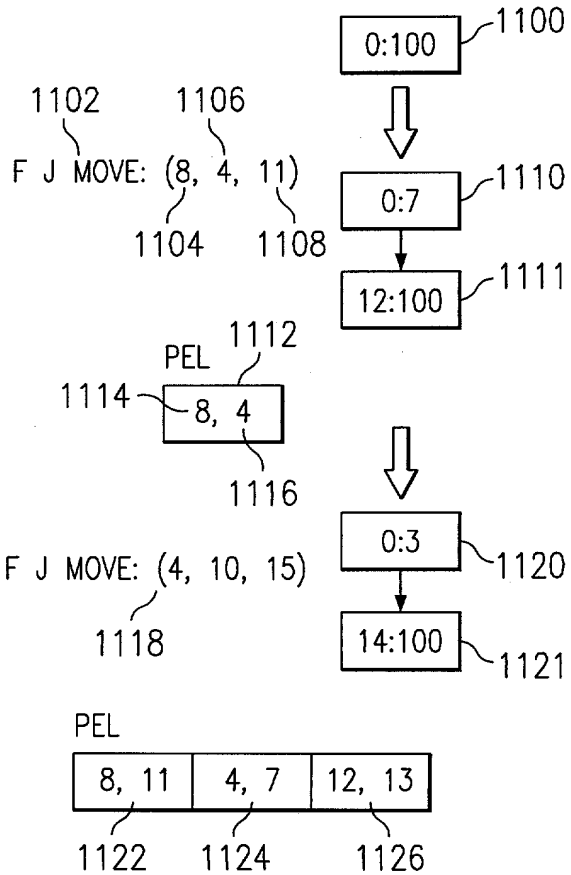


FIG. 11



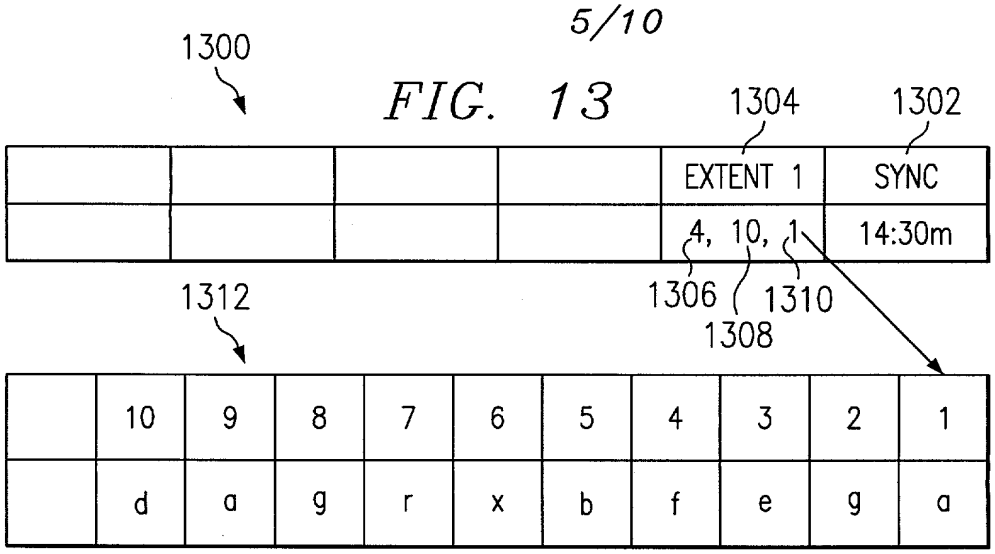


FIG. 13

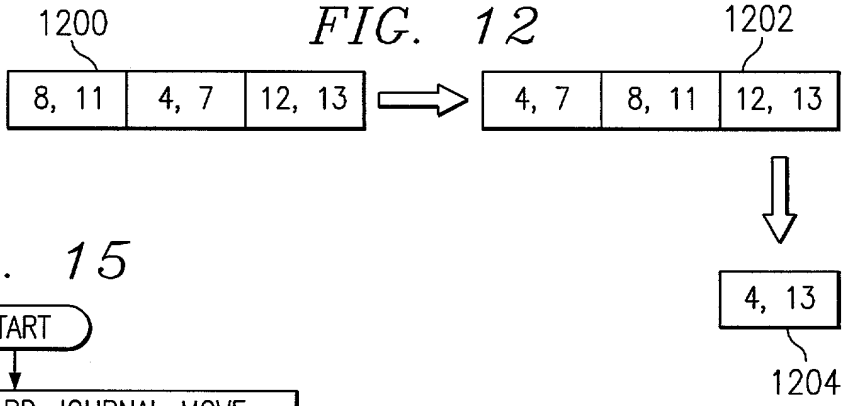


FIG. 12

FIG. 15

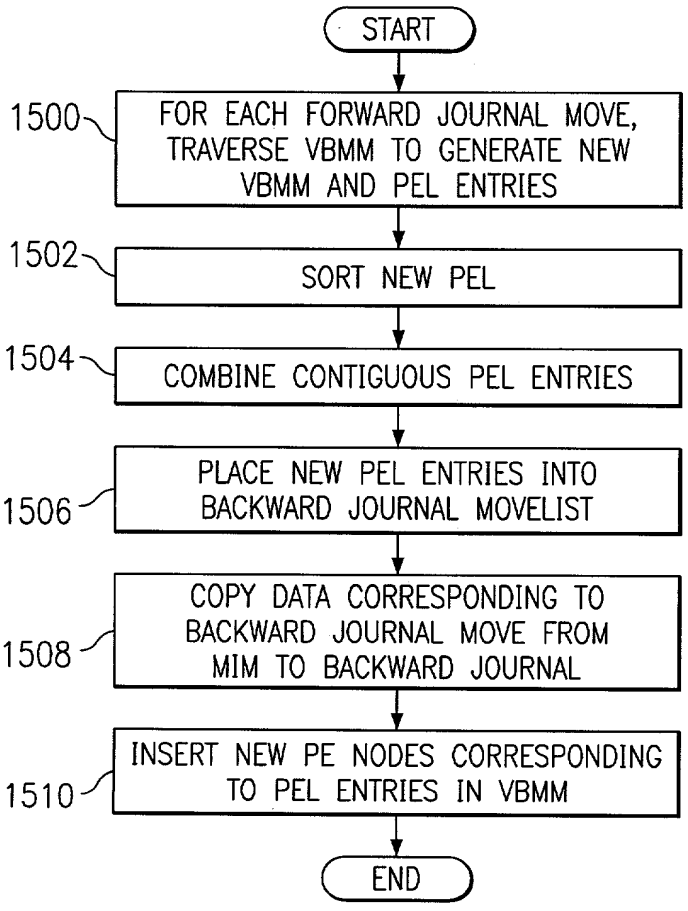
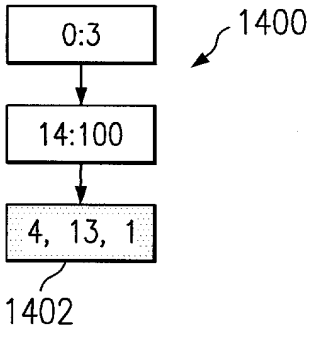


FIG. 14



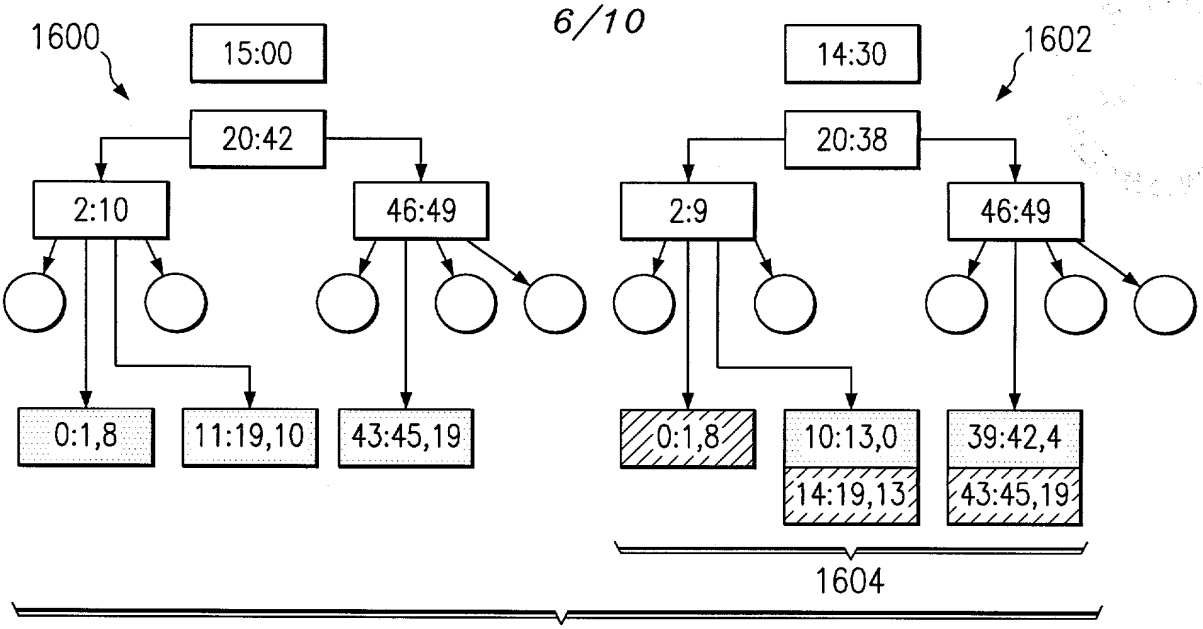

1600
15:00
20:42
2:10
46:49
0:1,8
11:19,10
43:45,19
14:30
1602
20:38
2:9
46:49
0:1,8
10:13,0
14:19,13
39:42,4
43:45,19
1604

FIG. 16

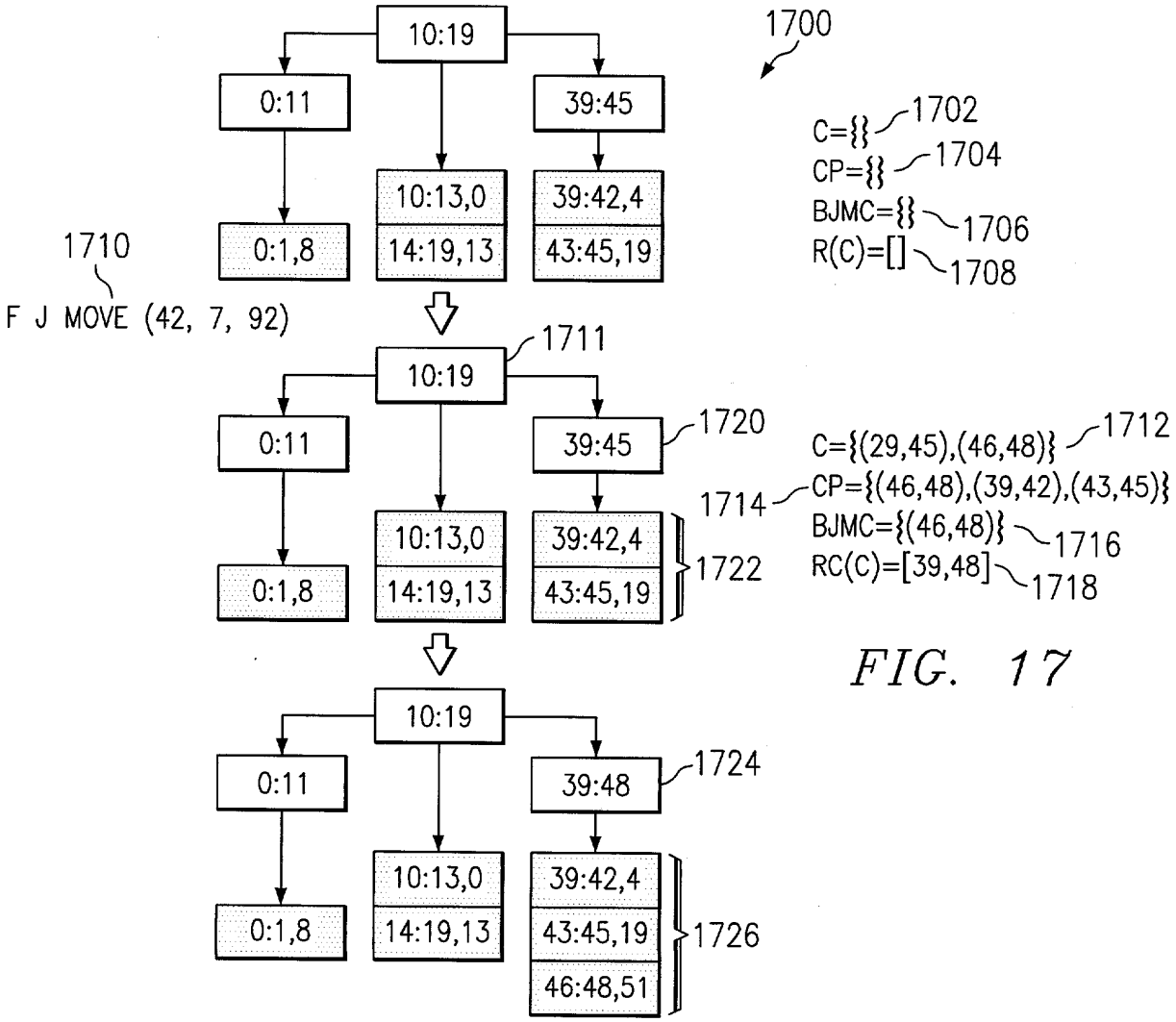

1700
10:19
0:11
39:45
0:1,8
10:13,0
14:19,13
39:42,4
43:45,19
C={}
1702
CP={}
1704
BJMC={}
1706
R(C)=[]
1708
1710
F J MOVE (42, 7, 92)
1711
10:19
0:11
39:45
1720
0:1,8
10:13,0
14:19,13
39:42,4
43:45,19
1722
C={(29,45),(46,48)}
1712
1714
CP={(46,48),(39,42),(43,45)}
BJMC={(46,48)}
1716
RC(C)=[39,48]
1718
10:19
0:11
39:48
1724
0:1,8
10:13,0
14:19,13
39:42,4
43:45,19
46:48,51
1726

FIG. 17

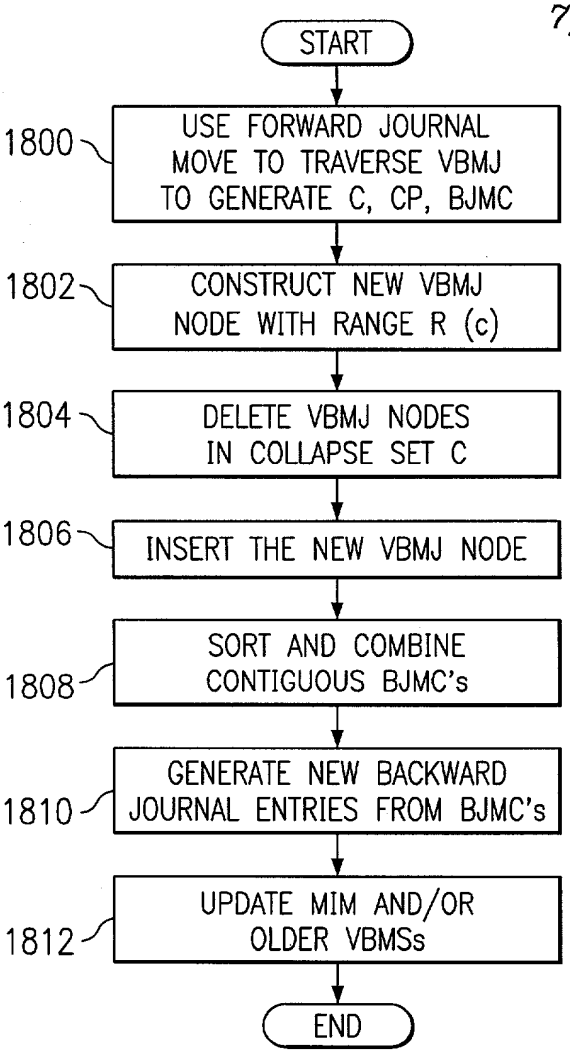
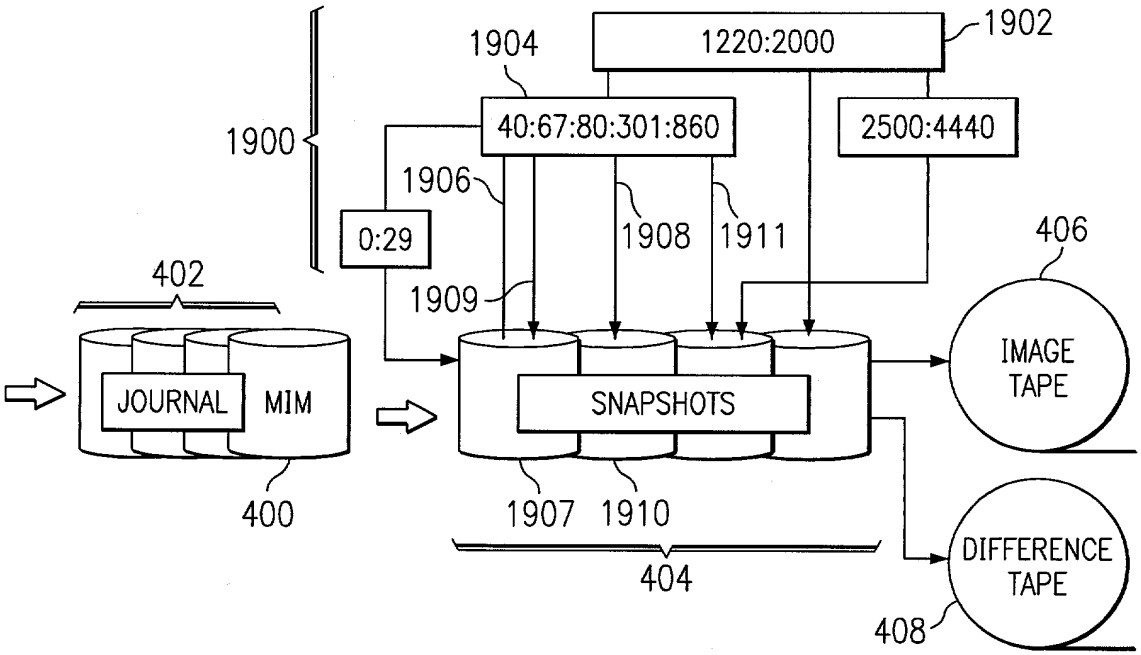

START
1800
USE FORWARD JOURNAL MOVE TO TRAVERSE VBMJ TO GENERATE C, CP, BJMC
1802
CONSTRUCT NEW VBMJ NODE WITH RANGE R (c)
1804
DELETE VBMJ NODES IN COLLAPSE SET C
1806
INSERT THE NEW VBMJ NODE
1808
SORT AND COMBINE CONTIGUOUS BJMC's
1810
GENERATE NEW BACKWARD JOURNAL ENTRIES FROM BJMC's
1812
UPDATE MIM AND/OR OLDER VBMSs
END

FIG. 18

FIG. 19


1900
1904
1220:2000
1902
40:67:80:301:860
2500:4440
1906
0:29
1908
1911
406
402
1909
JOURNAL
MIM
SNAPSHOTS
IMAGE TAPE
400
1907
1910
404
DIFFERENCE TAPE
408

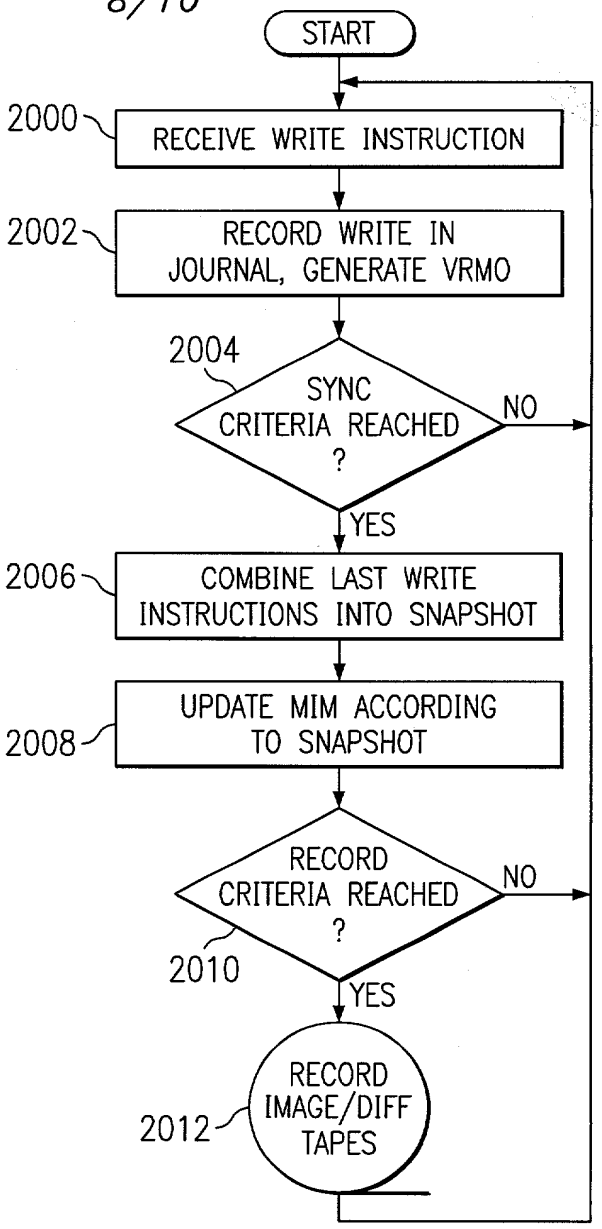

START
2000
RECEIVE WRITE INSTRUCTION
2002
RECORD WRITE IN JOURNAL, GENERATE VRMO
2004
SYNC CRITERIA REACHED ?
NO
YES
2006
COMBINE LAST WRITE INSTRUCTIONS INTO SNAPSHOT
2008
UPDATE MIM ACCORDING TO SNAPSHOT
RECORD CRITERIA REACHED ?
NO
2010
YES
RECORD IMAGE/DIFF TAPES
2012

FIG. 20

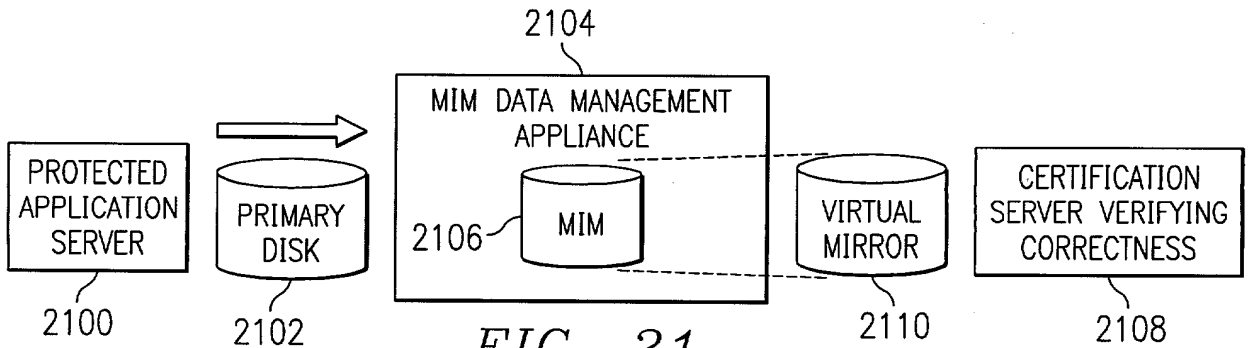

2104
MIM DATA MANAGEMENT APPLIANCE
PROTECTED APPLICATION SERVER
PRIMARY DISK
2106
MIM
VIRTUAL MIRROR
CERTIFICATION SERVER VERIFYING CORRECTNESS
2100
2102
2110
2108

FIG. 21

FIG. 22

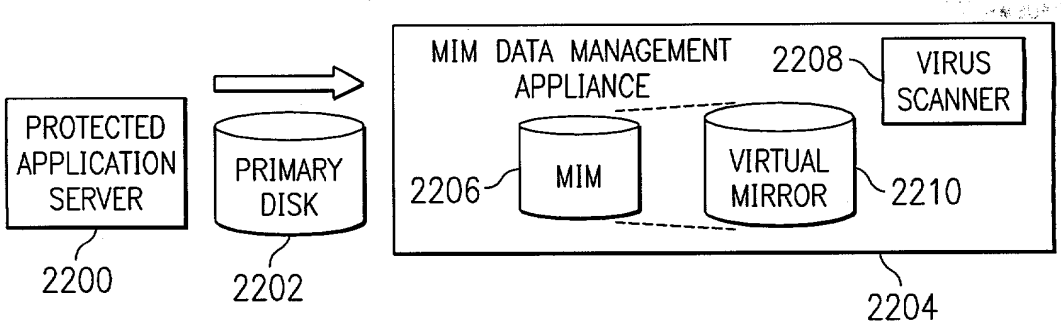
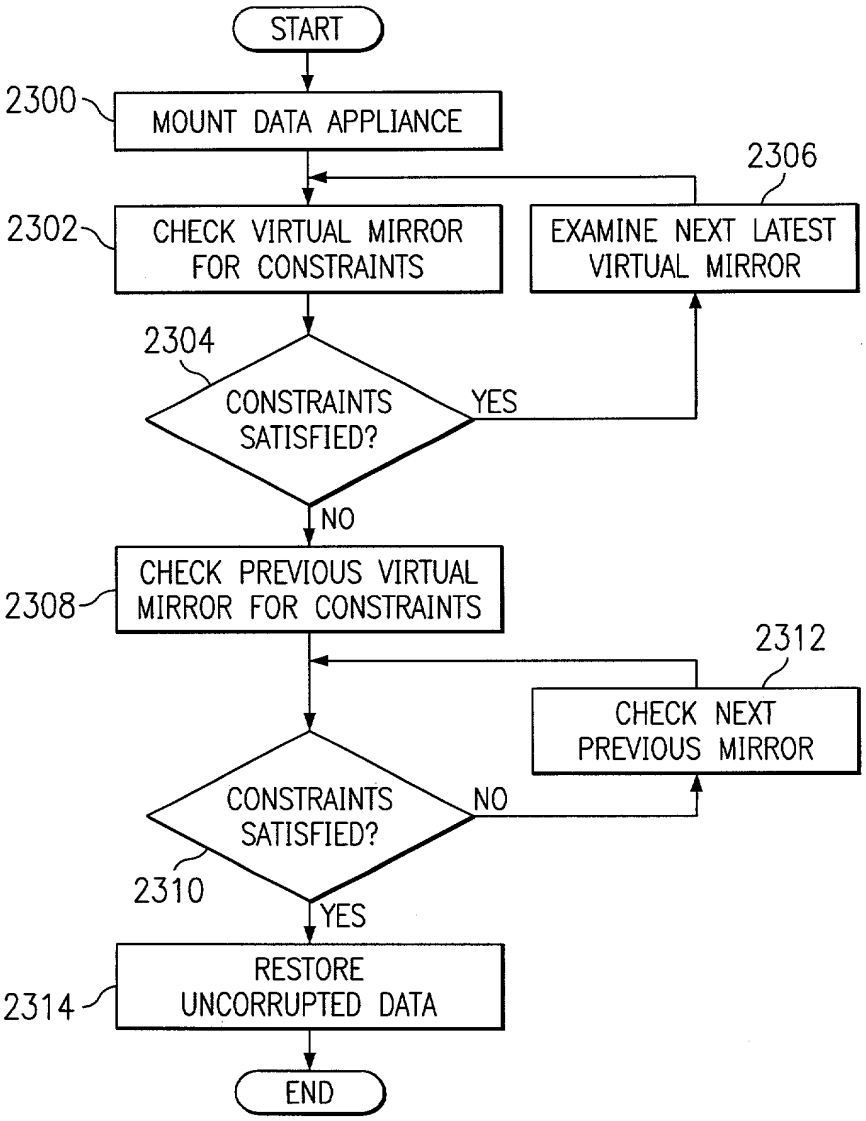

PROTECTED APPLICATION SERVER
2200
PRIMARY DISK
2202
MIM DATA MANAGEMENT APPLIANCE
2208
VIRUS SCANNER
2206
MIM
VIRTUAL MIRROR
2210
2204

FIG. 23


START
2300
MOUNT DATA APPLIANCE
2306
2302
CHECK VIRTUAL MIRROR FOR CONSTRAINTS
EXAMINE NEXT LATEST VIRTUAL MIRROR
2304
CONSTRAINTS SATISFIED?
YES
NO
2308
CHECK PREVIOUS VIRTUAL MIRROR FOR CONSTRAINTS
2312
CHECK NEXT PREVIOUS MIRROR
CONSTRAINTS SATISFIED?
NO
2310
YES
2314
RESTORE UNCORRUPTED DATA
END

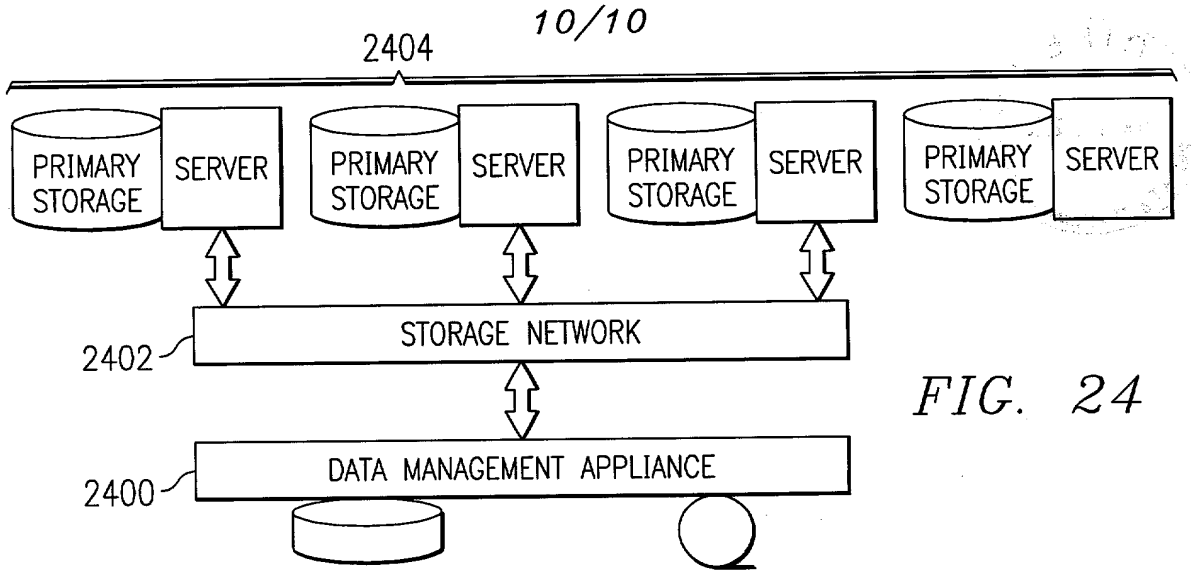


FIG. 24

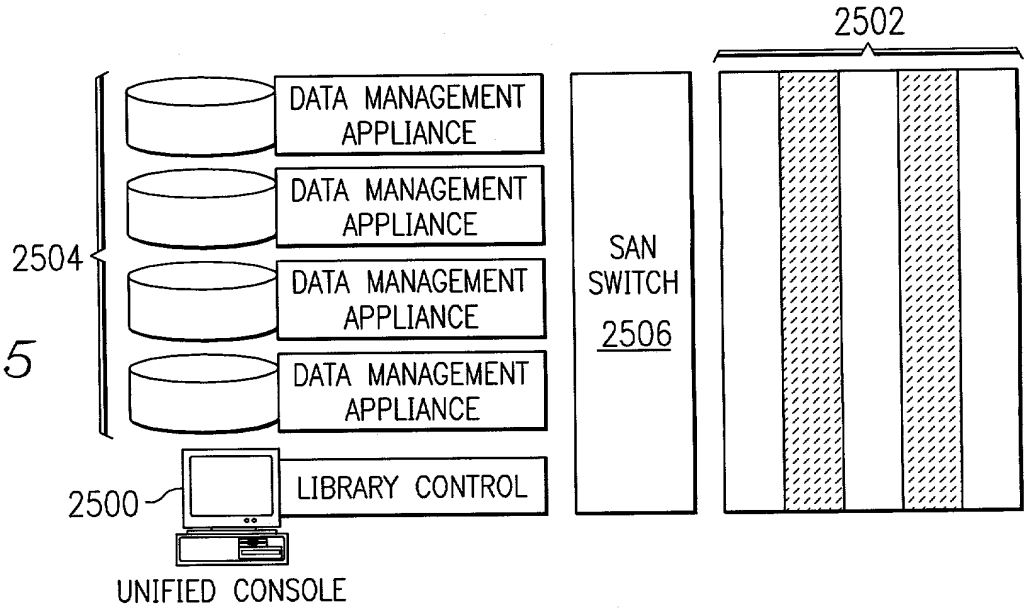


FIG. 25

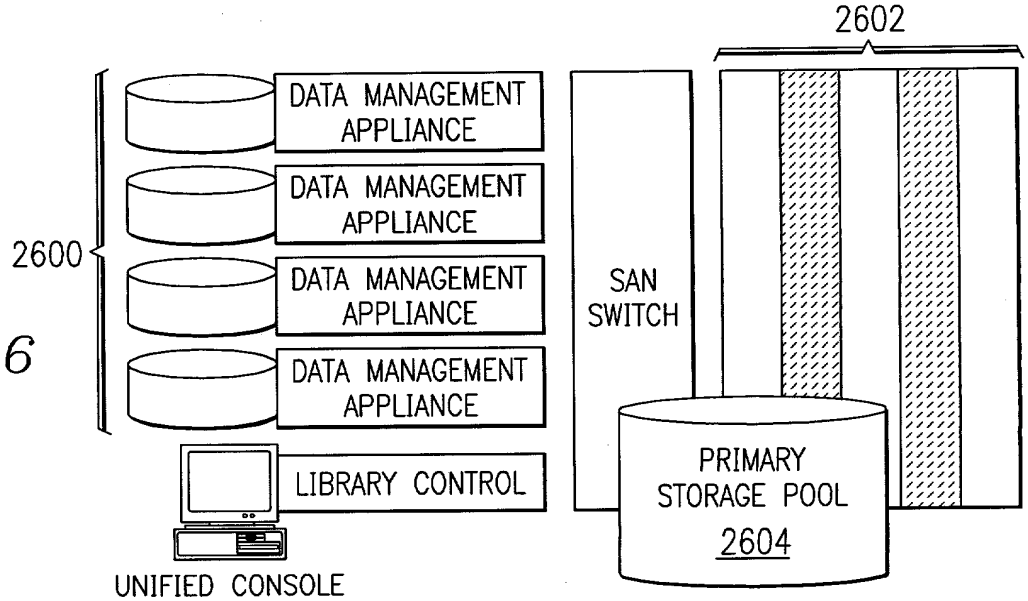


FIG. 26